

**APPARATUS, AND ASSOCIATED METHOD, FOR FACILITATING
COMMUNICATION OF UNFRAGMENTED PACKET-FORMATTED DATA IN A
RADIO COMMUNICATION SYSTEM**

The present invention relates generally to a manner by which to facilitate communication of packet-formatted data in a radio communication system in unfragmented form. More particularly, the present invention relates to apparatus, and an associated method, by which to
5 determine, at a network part of the radio communication system, on behalf of a mobile host that is to send the packet-formatted data, a packet size that permits the packet-formatted data to be sent in unfragmented form to a correspondent host. Once determined, an indication of the permitted packet size is sent to the mobile host.

Because determination of the permitted packet size is performed at the network part and
10 not at the mobile host, only minimal amounts of radio resources are needed to make the determinations. And, the computations required of a processing element of the mobile host are also minimal.

A network-based proxy is utilized to make determinations on behalf of the mobile host. An ICMPv6, or other appropriate, message is formed and sent to the mobile host that contains
15 indications of the determinations. Packet-formatted data subsequently sent by the mobile host are of packet sizes selected responsive to the determinations.

Background of the Invention

Modern communication systems are endemic throughout modern society. The need to communicate data is pervasive, and ready access to a communication system through which to
20 communicate is regularly required. As additional communication services become available, the need to have ready access to a communication system to communicate therethrough to effectuate the additional communication services shall likely increase.

In general, a communication system includes a set of communication stations. At least one communication station of the set forms a sending station, and at least another communication station of the set forms a receiving station. Communication data is communicated by a sending station to a receiving station by way of a communication channel.

5 The sending station converts, if necessary, the communication data into a form to permit its communication upon the communication channel, and the receiving station includes circuitry to provide for the recovery of the informational content of the communication data delivered thereto.

A radio communication system is a communication system in which the communication
10 channel upon which the communication data is sent is defined upon a radio link extending therebetween. The communication channels are referred to as radio channels. Because the radio channels are defined upon radio links, the conventional need to form a wireline connection between communication stations to effectuate communications therebetween is obviated.

Because wireline connections are not required to be formed between communication
15 stations, communications are effectuable by way of a radio communication system between locations at which communications by way of a conventional wireline communication system would be inconvenient or impractical. Additionally, because no wireline connection is required to be formed with the communication stations, a radio communication system is amenable for implementation as a mobile communication system. In a mobile communication system,
20 communication mobility is provided. That is to say, one or more of the communication stations of a mobile communication system is mobile and is not limited to operation at a fixed position.

A cellular communication system is a type of mobile communication system. The networks of various cellular communication systems have been deployed throughout large

geographical areas of the populated portions of the world. A cellular communication system provides for telephonic communications, of both voice data and non-voice data. Successive generations of cellular communication systems have been developed and deployed. New-generation systems are currently being deployed and others are under development. For

5 instance, standardization of so-called new generation (NG) systems and operating protocols are ongoing. In general, the new generation communication systems utilize digital communication techniques and communicate packet-formatted data. When packet-formatting is used, data is communicated in the form of data packets, sometimes utilizing shared communication channels.

Packet formatting protocols have also been standardized, and such protocols are used by
10 which to format data packets that are communicated in a cellular communication system. A packet formatting protocol defines the format of a data packet. IP (Internet Protocol) formatting that is currently used is generally in conformity with a version 4 of the Internet Protocol, IPv4. A successor protocol, referred to as new generation protocol, IPng, has been standardized and is undergoing implementation. The new generation protocol is referred to as version 6, IPv6.

15 Packet-formatted data, formatted pursuant to the IPv6 standard, is an evolutionary standard that is compatible with the IPv4 standard. IPv6-formatted data packets are of selectable lengths.

The length permitted of a data packet is limited by the maximum number of bytes of data that are permitted to be communicated in a single transmission, e.g., packet, on a communication length to a correspondent device. If a packet is transmitted that is too large to be delivered as a
20 single packet to a correspondent device, the packet can be resent in fragmented form, i.e., as separate parts that are subsequently concatenated together. When a packet must be fragmented and retransmitted, however, increased processing loads are imposed upon entities associated with the communication of the data packet to the correspondent device. Additional problems, such as

reduced throughput rates also result. To reduce the possibility that a data packet that is too large to be delivered successfully to a correspondent device, a path MTU (Maximum Transmission Unit) discovery procedure is carried out. In a path MTU discovery procedure, a procedure is carried out by which a determination is made of the maximum path MTU. And, when the path
5 MTU is determined, the data packets that are subsequently formed are selected to be of lengths that do not exceed the length of the path MTU. The path MTUs might change as a result in changes of length configurations, and the path MTUs must be re-calculated, as needed.

The path MTU discovery procedure was first used for packet communications in conventional, wireline communication systems. While the same discovery procedure is
10 amenable for implementation in a radio communication system, the conventional path MTU discovery procedure is relatively bandwidth consumptive, a problem in a bandwidth-constrained system, such as a cellular communication system.

If a manner could be provided by which better to perform a path MTU discovery procedure, or other analogous procedure, that requires less use of radio resources, better use
15 could be made of the limited bandwidth available in a radio communication system.

It is in light of this background information related to packet radio communication systems that the significant improvements of the present invention have evolved.

Summary of the Invention

The present invention, accordingly, advantageously provides apparatus, and an associated method, by which to facilitate communication of packet-formatted data in a radio communication system in unfragmented form.

5 Through operation of an embodiment of the present invention, a manner is provided by which to determine, at a network part of the radio communication system, on behalf of a mobile host that is to send the packet-formatted data, a packet-size that permits the packet-formatted data to be sent in unfragmented form by a sending host to a correspondent host. Once the packet size is determined at the network part, an indication of the permitted packet size is sent upon a
10 radio channel to the mobile host.

A proxy is provided at the network part on behalf of the mobile host to perform the determination of the permitted packet size of data packets that are to be communicated by way of a link with a correspondent host. The permitted packet size is determined by the proxy, for instance, by sending sample packets to the correspondent host to determine the permitted packet
15 size that can be sent by way of a link to the correspondent host. The initial size of the sample packet sent by the proxy is locally selected, i.e., a local maximum packet size or selected remotely, e.g., at the correspondent host, or the lesser of the two permitted packet sizes. A packet of the selected packet size is sent by the proxy to the correspondent host. If the packet of the selected size cannot be delivered to the correspondent host in unfragmented form, an error
20 message is returned to the proxy. The error indicates that the selected packet size is too large. The proxy reselects the packet size to be of a reduced packet size. The process is repeated until the packet is delivered to the correspondent host without return of an error message. The packet

size of the packet determined to have been delivered to the correspondent host defines the selected packet size.

A control message is formatted and populated with a value representative of the packet size determined by the proxy of which a packet is able to be communicated to the correspondent
5 host in unfragmented form. The control message is sent by way of a radio channel to the mobile host. The mobile host detects the control message and extracts the values contained therein. The mobile host utilizes the extracted values to set a maximum packet length of packets formatted thereat for communication to the correspondent host.

Because the mobile host need not perform the determination procedure by which the
10 allowable packet size is determined and such determinations are instead made by a network-positioned proxy entity, various advantages result. The sample packets that are formed and sent pursuant to the determination of the allowable packet size are sent by the network-positioned proxy device rather than the mobile host, reduced radio resources are required pursuant to the determination. And, because the processing associated with the determination is also performed
15 at the proxy rather than at the mobile host, reduced energy consumption of the mobile host results. Also, limited available memory capacity at the mobile host need not be dedicated for the determination procedure.

The message generated at the network part, such as at the same proxy that determines the permitted packet size of packets that are to be communicated to a particular correspondent host
20 by way of a particular link, includes an indication of the permitted packet size as well as an indication in the header part of the message of the message-type. That is to say, the message includes an indication in its header portion that the message contains, in its body, the permitted packet size. The message further includes, for instance, an identifier, such as the IP address, that

identifies the correspondent host as well as the length by which the packet data is to be communicated thereto.

When utilizing the IPv6 protocol and an associated ICMPv6 protocol, a new ICMPv6 message is formed and communicated to the mobile host. The permitted packet size forms a path MTU (Maximum Transmission Unit) value that defines the maximum packet size that the mobile host can send to the correspondent host over a selected length without fragmentation of the packet. The ICMPv6 message is formatted in conventional manner to include a header part and a body part. The header part includes a type field that is populated with a value, such as 143, that identifies the message to be a message identifying the path MTU value associated with a particular correspondent host and communication length. In one implementation, the ICMPv6 message further includes path MTU values associated with other correspondent hosts or other communication links to indicate to the mobile host that receives the message the allowable packet sizes to be used pursuant to sending communication data packets to the associated correspondent host.

In another aspect of the present invention, a cache is maintained for storing values of the permitted packet sizes, such as the path MTUs that are discovered pursuant to a path MTU discovery (PMTU-D) procedure. The cache is maintained, for instance, together with the proxy at the network part or is maintained at the mobile host, or at both locations. The values stored at the cache, when embodied at the network part, are used, if needed, to populate the ICMP message or, if embodied at the mobile host, are used when the data packets are formatted to determine the size permitted of the packets.

In these and other aspects, therefore, apparatus, and an associated method, is provided for a packet radio communication system. The packet radio communication system is operable

pursuant to an Internet Protocol (IP). And, the radio communication system has a mobile host and a network part. The mobile host communicates with at least a first correspondent host that is connected in communication connectivity with the network part. Communication of packet-formatted data is facilitated by the mobile host in unfragmented form. A network position determiner is operable responsive to initiation of communications by the mobile host. The network position determiner determines, on behalf of the mobile host, of at least a first packet size into which the packet-formatted data is permitted to be formed for communication to the at least the first correspondent host. The at least the first packet size determined by the network position determiner permits communication of the packet-formatted data in unfragmented form to the at least the first correspondent host.

A more complete appreciation of the present invention and the scope thereof can be obtained from the accompanying drawings that are briefly summarized below, the following detailed description of the presently-preferred embodiments of the present invention, and the appended claims.

Brief Description of the Drawings

Figure 1 illustrates a functional block diagram of a radio communication system in which an embodiment of the present invention forms a portion.

Figure 2 illustrates a message sequence diagram representative of signaling generated
5 during operation of the radio communication system shown in Figure 1.

Figure 3 illustrates the format of an exemplary notification message generated pursuant to an embodiment of the present invention.

Figure 4 illustrates a method flow diagram listing the method steps of the method of operation of an embodiment of the present invention.

Detailed Description

Referring first to Figure 1, a radio communication system, shown generally at 10, provides for radio communications with, and by, mobile hosts, of which the mobile host 12 is representative. In the exemplary implementation, the communication system forms a cellular packet radio communication system that provides for IPv6 packet-formatted communications. While the following description shall describe exemplary operation of the present invention with respect to its implementation in a cellular packet radio communication system that utilizes IPv6 link layer protocol, the teachings of the present invention are analogously also implementable in other types of communication systems and operation of an embodiment of the present invention can analogously be described with respect to its implementation in other communication systems.

The communication system also includes a network part with which the mobile host communicates by way of radio channels defined upon radio links. The arrow 14 is representative of a radio link upon which radio channels are defined. Communication data, originated at the network part of the communication system is communicated upon downlink channels defined upon radio downlinks. And, communication data originated at the mobile host is communicated upon uplink channels defined upon radio uplinks. Packet-formatted data originated at the mobile host, for instance, is communicated upon uplink channels and detected at the network part, subsequently to be routed thereto to a destination.

The network part of the communication system includes a radio access network (RAN) portion 22. The radio access network portion includes a base transceiver station (BTS) 24 that includes radio transceiver circuitry capable of sending communication data to, and detecting communication data communicated by, the mobile host. While only a single base transceiver

station is shown in the figure, in a typical radio access network, a plurality of spaced-apart base transceiver stations are utilized, each of which defines a coverage area referred to as a cell. The cells defined by the base transceiver stations collectively define the coverage area of the radio communication system. When a mobile host, such as the mobile host 12, is positioned within the coverage area defined by any of the cells associated with any of the base transceiver stations, communication data is able to be communicated between the mobile host and the network part of the communication system.

The radio access network portion 22 of the network part of the communication system includes other functional entities, such as a radio network controller (RNC) 26. The radio network controller is coupled to a group of base transceiver stations, of which the base transceiver station 24 is representative, and operates, amongst other things, to control operation of the base transceiver stations coupled thereto.

The network part of the communication system further includes a packet data network portion 28 to which the radio access network portion is coupled by way of a packet data service node (PDSN) 32. The packet data network portion forms a communication fabric through which communication data, here packet-formatted communication data, is communicated.

Various functional entities are coupled to, or form parts of, the packet data network. An edge router 34 is here shown to be coupled to the packet data network. The edge router performs routing functions to route packet-formatted communication data communicated during operation of the communication system. The router is coupled to an IPv6 network 36 and, by way of a router 38, to an IPv6 external services network 42 to which a correspondent host (CH) 44 is connected. The correspondent host is an IPv6 host.

A communication path is formable between the mobile host 12 and the correspondent host 44 through which to communicate packet-formatted data to effectuate a communication service. The communication system also includes a DNS (domain name service) server 46 and an operator Ipv6 services server 48, here at least functionally connected to the edge router 34.

5 As noted previously, data packets are preferably communicated in unfragmented form to reduce the need to retransmit fragments of the data packet. While existing proposals related to the IPv6 protocol provide for a path MTU discovery procedure, such procedure is performed by a sending host, here, e.g., the mobile host. As the path MTU discovery procedure utilizes the transmission of sample packets to determine the path MTU size, radio resources are required to
10 be utilized each time in which a sample packet is communicated upon a radio channel defined upon a radio link. As the radio air interface that defines the radio link is typically bandwidth-constrained, there is an ongoing need to minimize the radio resources available upon the radio channels upon the radio link to the communication of the packet-formatted data.

Pursuant to an embodiment of the present invention, apparatus, here indicated by
15 elements positioned within the block 52, is provided. The apparatus forms a proxy, on behalf of the mobile host, to perform the path MTU discovery procedure and to notify the mobile host of the permitted packet size determined therefrom, i.e., the path MTU. In the exemplary implementation, the apparatus is embodied at the packet data service node 32. In other implementations, the apparatus is embodied elsewhere. The functional entities forming the
20 apparatus here include a determiner 54, a notifier 56, and a cache memory 58. The entities are functional and are implementable in any desired manner such as by algorithms executable by processing circuitry.

The determiner operates responsive to initiation of communications by the mobile host to initiate a communication session with a mobile host. The mobile host initiates communication, here, by the transmission of a DNS (Domain Name Server) inquiry that is communicated to the domain name server 46. Once routed to the domain name server, the domain name server
5 determines an IP address associated with the correspondent host. And, the domain name server generates a response to indicate the IP address associated with the domain name contained in the request. When the response is delivered to the packet data service node, the response is intercepted by the apparatus 52, and the determiner commences operation to determine the path MTU by performing the path MTU discovery procedure.

10 In the exemplary implementation, the determinations made by the determiner are provided to the notifier 56 and also cached at the cache memory 58. Storing of the determined values of the permitted packet size at the cache memory permits its later retrieval, if needed.

The notifier operates to form an ICMPv6 message that is routed through the radio access network portion and sent to the mobile host to inform the mobile host of the path MTU size
15 permitted of data packets subsequently to be formed and sent by the mobile host to the correspondent host. The message is also formatted to include the identity, such as by its IP address, of the correspondent host as well as the communication link for which the path MTU is associated. The mobile host, upon detection of the message, extracts the information therefrom, and formats data packets in conformity with the path MTU value. By constructing the data
20 packets in conformity with the path MTU value, the data packets are able to be communicated, in unfragmented form, to the correspondent host.

Thereby, as the path MTU is determined at the network part of the communication system, not the mobile host, radio resources are conserved and the computational processing, otherwise required to be performed at the mobile host, is performed at the network part.

Figure 2 illustrates a message sequence diagram, shown generally at 72, representative of the signaling generated during operation of the packet radio communication system 10 shown in Figure 1. The operation and signaling generated is representative of operation of the communication system when communications are initiated by the mobile host 12 to send packet-formatted communication data to the correspondent host. The communication system operates pursuant to an embodiment of the present invention by which the path MTU is determined at the network part of the communication system rather than at the mobile host. By performing the path MTU discovery procedure at the mobile host, the radio resources that are required to carry out the path MTU discovery procedure are reduced.

First, and as indicated by the segments 74 and 76, LCP (Link Control Protocol) and IPCPv6 (Internet Protocol Command Protocol Six) procedures are carried out to form a link between the mobile host and the packet data service node 32. Responsive to the signaling, and as indicated by the block 78, the link is opened for the communication of packet-formatted data, here IP traffic.

When communication data is to be communicated by the mobile host to the correspondent host, the mobile host first generates and sends a DNS (Domain Name Source) query, indicated by the segment 82, to the packet data service node and, subsequently, routed, indicated by the segment 84, through the packet data network to the DNS server 46. The domain name server determines the IP address associated with the domain name contained in the DNS query and forms a DNS response, indicated by the segment 86, that is returned to the packet data

service node. The apparatus 52 of an embodiment of the present invention intercepts the DNS response. And, the DNS response is also returned, indicated by the segment 88, to the mobile host.

The proxy function performed by the apparatus 52 includes performing the path MTU discovery procedure, here through the generation of the path MTU discovery messages sent, indicated by the segment 92, by way of a communication link to the correspondent host 44. Replies are generated and returned, indicated by the segment 96, indicative of whether a fragmentation error is generated, viz., indicating whether a sample packet previously sent is of a too large of a packet size.

The proxy further forms and sends a ICMPv6 message of an embodiment of the present invention, here indicated by the segment 98, to the mobile host. The message is formatted to include the path MTU value that is determined by the proxy together with the IP address as well as, if desired further, the communication link upon which the path MTU is determined, to the mobile host. The message is populated, in one implementation, with multiple values of path MTU values and associated multiple numbers of IP addresses and multiple communication links.

Figure 3 illustrates an exemplary format of an ICMPv6 message that is generated pursuant to an embodiment of the present invention by which to notify a mobile host of the determined path MTU indicating the maximum packet size permitted of packets generated by the mobile host without fragmentation. The message 102 includes a header part including a type field 104, a code field 106, and a checksum field 108. The message further includes a message body 112 populated with one or more IP addresses 114 and associated path MTU values 116. The message includes further fields including an address type field 122, a record number field 124, and a record value field 126.

Figure 4 illustrates a method, shown generally at 142, of the method of operation of an embodiment of the present invention. The method facilitates communication of packet formatted data by a mobile host in unfragmented form to a correspondent host.

5 First, and as indicated by the block 144, a determination is made at the network part, on behalf of the mobile host, of at least a first packet size into which the packet formatted data is permitted to be formed for communication to the correspondent host. The first packet size permits communication of the packet formatted data in unfragmented form to the first correspondent host.

10 Then, and as indicated by the block 146, the mobile host is notified of the at least the first packet size permitted of the packet formatted data.

Because the determination is made at the network part of the communication system, lessened levels of radio resources are required pursuant to the permitted packet size discovery process. And, as the processing associated with the determination is performed at the network rather than at the mobile host, processing responsibility at the mobile host is alleviated.

15 The previous descriptions are of preferred examples for implementing the invention, and the scope of the invention should not necessarily be limited by this description. The scope of the present invention is defined by the following claims.